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EDITORIAL

FUNGI AND DISEASE

DURING the last four or five decades many of the mysteries of the past have been explained and resolved. This has been the case most particularly in regard to the fight against disease. Some diseases which have ravaged the world for centuries have been eliminated, others have been brought under control and so shorn of much of their terror.

Beneficent nature is a good friend of man, but rebellious nature can be a stubborn and persistent foe who will react quickly and vehemently when attacked. If her front line be breached then, as is the case in a war waged by man, she will react with vigour and sometimes with greater stamina and virulence. Her agents or troops are represented by diseases. It may be that she is content to exacerbate the virulence of the original process; on the other hand she may introduce some apparently new disease. In some cases she will retaliate with an old and well-known disease which in the past has been of little moment yet which, when the time and environment are favourable, can increase in strategic and lethal importance.

Clinicians have frequently noted that it is unusual for the animal body to be attacked by two "major" diseases simultaneously. It may be that the metabolic changes or disturbance excited by one disease are not propitious for the propagation of a second. This theory has been applied and with some success in both prophylaxis and treatment. It may be that the results achieved are in certain ways linked with the interference phenomenon which has been observed in some virus diseases. The use of the malarial parasite in the treatment of General

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Paralysis of the Insane is another example of the application of this idea in therapeutic practice.

In recent times attention has been drawn to the apparent increase in various disease processes which can be attributed to the infection or invasion of the tissues by fungi. The first experimental proof that such an organism could cause disease was offered by Bassi in 1835 when he showed that muscardine disease of silkworms was caused by a fungus. In 1839 Schoenlein described the fungus which causes favus, and Lagenbuck that which was responsible for thrush in man.

The work of Pasteur, Lister, Koch and Colin in the bacteriological field, and later work on protozoa and viruses as animal pathogens has tended to eclipse the consideration of fungi as a potent factor in animal diseases other than those affecting the integument.

In recent years owing to the failure of bacteriologists to explain certain disease processes which affect the chest, and encouraged by the observations of clinicians who are more interested in the host reactions, a considerable amount of work has been done on the fungi. The latter are responsible for some of the pathological processes which affect the lungs. The search for new antibiotics has also added greatly to the store of mycological knowledge.

Many fungi have been described as causing disease in man and animal. They can be divided into two groups, (1) those which are normally associated with animals and (2) those which occur naturally as saprophytes in the animal environment and can become pathogenic when conditions are favourable. To this latter group belong most of the systemic mycoses such as aspergillosis and sporotrichosis. Many of the successful pathogens are normally associated with their animal hosts and are well-adapted to their parasitic mode of life. They give rise to superficial lesions which seldom kill or even seriously injure the host. As a rule these infections do not give rise to great concern for the therapeutic measures necessary to control and eliminate them are known.

It is so-called systemic infections by fungi which are of ever-increasing importance and particularly those which exert their pathogenic effects on the respiratory and alimentary systems. Avian aspergillosis can be cited as being one disease of great economic importance. No doubt as research work proceeds it may be found that systemic fungoid infections occur with relative frequency in the other domesticated animals, and the knowledge gained may open another door in the attack upon disease, a door which may prove to be as wide as that which was disclosed by bacteriologists.

GENERAL ARTICLES

INHIBITION OF THE GROWTH OF STREPTOCOCCUS PYOGENES IN ROLL TUBES

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Introduction

DURING the course of experiments on the antibacterial properties of milk, which involved the counting of Lancefield's Group A streptococci in blood agar roll tubes, a curious inhibition of growth was noted. Whereas roll tubes showing normal growth had colonies evenly distributed throughout the medium, affected tubes exhibited growth only in their uppermost limits, i.e., towards the open end of the tube. Graduations in this condition were observed, ranging from complete failure of growth to a state approaching normal growth, except that fewer organisms were present than in control tubes, which had been sown simultaneously with corresponding dilutions of the same culture, and no growth occurred within ½ in. to 1 in. of the closed end of the tube. Notwithstanding these variations, most of the affected roll tubes showed growth only in the uppermost ½ in. of the medium.

Since the repeated occurrence of this phenomenon interfered seriously with the work concerned, an attempt was made to find the factors responsible and this paper gives details of some of the experiments made.

Technique

An old laboratory strain of *Str. pyogenes,* which had been maintained in meat-piece broth for some years, was employed and a loopful of this stock culture was sown into serum broth and incubated overnight at 37° C. This 18-24 hour culture was shaken thoroughly immediately before being used to prepare a series of ten-fold dilutions in peptone broth, employing the same pipette throughout; exact counts were not required and this procedure saved both time and materials. Very occasionally, a culture in serum broth was used after standing for a further 24 hours on the bench, as trials showed no appreciable difference between such cultures and those fresh from overnight incubation.

In the early experiments, each series of roll tubes was inoculated with every dilution of culture from 10^{-1} to 10^{-6}. Subsequently, it was found that the use of fewer dilutions did not affect the accuracy of the results, and only the 10^{-3}, 10^{-4} and 10^{-6} dilutions were used.

Approximately 2 mls. of nutrient agar were placed in 6 in. x $\frac{5}{8}$ in. test tubes and stocks of these tubes were then held in a cold store until needed. When required, the test tubes were placed in boiling water for the minimum period necessary to melt the agar (8 minutes) and were then transferred to a water bath at 50° C. After the test tubes had cooled to the temperature of the

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water bath, 0.2 ml. defibrinated sheep's blood was added to each tube, which was then ready for inoculation and rolling. Blood from one sheep was used for all the experiments and, when it became necessary to use a fresh batch of blood, duplicate sets of roll tubes were set up and old and new blood used.

In all these experiments, a standard inoculation of 0.1 ml. of culture dilution was used. The same pipette was employed for sowing every tube in an experiment, starting with the tubes receiving the 10^{-6} dilution of culture and proceeding through the descending series of dilutions. After rolling, the tubes were marked to show the dilutions of organisms sown, bunched in individual series by means of rubber bands, and transferred to the incubator. Except where otherwise stated, all the tubes had sterile, non-absorbent cotton-wool plugs and were incubated with the plugs downward, so that any excess moisture present ran from the medium on to the plugs.

The growth phenomenon described in this paper was originally observed in roll tubes incubated in a large incubator room maintained at a nominal 37.0° C. This room is heated by four electrically operated radiators, placed in pairs against the side walls. Two of these radiators, diagonal to one another, are constantly on, while the current to the other diagonal pair is operated by the incubator thermostat. Five tiers of racks are fixed to the side and end walls of the room and, unless stated otherwise in the text, the roll tubes were incubated in wire mesh crates on the uppermost rack over one of the constantly-heated radiators.

After overnight incubation, the roll tubes were removed and the number of colonies counted.

Results

All the results recorded were observed after several repetitions of the experiments described.

Experiment I

After the growth phenomenon described above had been observed in roll tubes incubated in the constant-temperature room, described, duplicate sets of roll tubes were placed in this room and in the incubator of an adjacent laboratory. A typical result is shown in Table I below.

TABLE I

Number of Colonies of Streptococcus pyogenes developing in Blood-agar Roll Tubes after Incubation at 37 C.

Dilutions of *Str. pyogenes*	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
After overnight in control incubator	Innumerable	Innumerable	< Innumerable	100	42	12
After overnight in incubator room	¼ in.	¼ in.	¼ in.	¼ in.	No growth	No growth

"Innumerable" = complete lysis of the blood in the medium, due to the presence of innumerable colonies.
<"Innumerable" = the presence of small patches of unhæmolysed blood.
Whole numbers = the number of colonies growing in the roll tubes.
"¼ in." = growth confined to the uppermost ¼ in. of the medium.

Duplicate sets of blood plates, sown with corresponding dilutions of culture, gave similar counts thereby demonstrating that this growth phenomenon was associated with the incubator room.

Experiment II

With the intention of studying the influence that inversion of the roll tubes during incubation might have upon growth and whether the non-absorbent cotton-wool plugs were implicated in the inhibition phenomenon, a series of roll tubes, without cotton-wool plugs, was placed in the incubator room. Alternate tubes were incubated in the upright position. A series of control tubes was treated similarly and placed in the control incubator (see Table II).

TABLE II

Number of Colonies of Streptococcus pyogenes in Roll Tubes of Blood-agar without Cotton-wool plugs.

Dilutions of *Str. pyogenes*	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
After overnight in control incubator	Innumerable	Innumerable	Innumerable	200	47	10
After overnight in incubator room	¼ in.	¼ in.	¼ in.	¼ in.	No growth	No growth

Roll tubes in both series containing the 10^{-2}, 10^{-4} and 10^{-6} dilutions were incubated upright; the others were inverted.

These results failed to show any difference between growth, in the same incubator, in inverted and upright roll tubes; the presence or absence of cotton-wool plugs had no effect on the growth. Irrespective of whether the roll tubes were inverted or upright during incubation, the surviving colonies in those tubes showing the inhibition phenomenon were confined to the medium towards the open end of the tube.

Experiment III

Roll tubes showing no growth or growth inhibition, after overnight in the incubator room, were transferred to the control incubator, but consistently showed indifferent growth after 24 hours re-incubation. It was, therefore, concluded that the majority of organisms had been killed during the initial incubation period.

Experiment IV

Uninoculated roll tubes were kept overnight in the incubator room, and were then streaked longitudinally with dilutions of *Str. pyogenes* and placed in the control incubator. Uniform growth was obtained and the result failed to give any evidence that a lethal factor was present in the medium.

Experiment V

Several series of roll tubes were placed in a variety of positions in the incubator room. The inhibition phenomenon or complete inhibition was noted

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in those tubes over one of the constantly-heated radiators, while growth was normal in the other series of tubes.

Fresh series of roll tubes were incubated simultaneously on each of the five racks immediately above one of the constantly-heated radiators. Those tubes on the bottom rack, nearest the radiator, repeatedly showed normal or only slightly reduced growth, while the degree of inhibition increased progressively on ascending racks (see Table III). A maximum-minimum thermometer on the rack immediately above the constantly-heated radiator showed a variation of 5° C. during overnight incubation (34.4° C.-39.4° C.).

TABLE III

Number of Streptococcus pyogenes Colonies developing in Roll Tubes incubated in different positions.

Dilutions of *Str. pyogenes*	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
Series in control incubator	Innumerable	Innumerable	Innumerable	Innumerable	200	37
Series on bottom rack of incubator room	Innumerable	Innumerable	Innumerable	Innumerable	139	36
Series on second rack of incubator room	Innumerable	Innumerable	Innumerable	Innumerable	262	40
Series on third rack of incubator room	Innumerable	Innumerable	Innumerable	Innumerable	200	¼ in.
Series on fourth rack of incubator room	Innumerable	Innumerable	¼ in.	¼ in.	1 in.	1 in.
Series on fifth rack of incubator room	1 in.	¼ in.	¼ in.	¼ in.	¼ in.	No growth

¼ in., ½ in. and 1 in. indicate growth confined to uppermost ¼ in., ½ in. or 1 in. of medium.

The walls of the incubator room had only recently been dressed with linseed oil and the growth inhibition on the higher racks could be due to a concentration in this region of some antibacterial vapour from the linseed oil.

Experiment VI

To test the hypothesis that the growth phenomenon might be due to an antibacterial vapour, the cotton-wool plugs of a series of roll tubes were replaced by sterile rubber bungs, after inoculation. The bungs were then immersed in a molten mixture of equal parts of paraffin wax and vaseline, to ensure air-tight sealing. These sealed tubes were then incubated with series of plugged tubes (see Table IV). For appearance of growth in sealed tubes, see Plate II.

Subsequent experience with sealed roll tubes showed that higher counts were almost always observed in these tubes when compared with the corresponding series of plugged roll tubes.

These results appeared to support the theory that an antibacterial vapour was, in part, responsible for this growth phenomenon.

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TABLE IV

Number of Colonies of Streptococcus pyogenes developing in tubes with different seals.

Dilutions of *Str. pyogenes*	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
Series in control incubator, plugged with cotton-wool	Innumerable	Innumerable	Numerous	150	38
Series in control incubator, sealed with rubber bungs	Innumerable	Innumerable	Innumerable	Numerous	90
Series in incubator room, plugged, 5th rack	Innumerable	Numerous	2	1	No growth
Series in incubator room, sealed, 5th rack	Innumerable	Innumerable	Innumerable	Numerous	70

"Numerous" = too many colonies to permit accurate counting.

Experiment VII

Series of plugged and sealed roll tubes were placed in two large tins ($9\frac{1}{2}$ in. x 9 in. x $13\frac{1}{2}$ in.) from each of which one end had been removed. These tins were put on the fifth rack in the incubator room, one having its open end downwards and the other having the open end upwards.

TABLE V

Number of Colonies of Streptococcus pyogenes developing under different conditions

Dilution of *Str. pyogenes*	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
Series in control incubator, plugged with cotton-wool	Innumerable	Innumerable	Numerous	200	41
Series in control incubator, sealed with rubber bungs	Innumerable	Innumerable	Innumerable	200	45
Series in incubator room, plugged, in inverted tin[1]	No growth	No growth	No growth	No growth	No growth
Series in incubator room, sealed, in inverted tin	Innumerable	Innumerable	Innumerable	200	41
Series in incubator room, plugged, in upright tin[2]	Innumerable	Innumerable	Innumerable	200	33
Series in incubator room, sealed in upright tin	Innumerable	Innumerable	Innumerable	200	66

1. Inverted tin had open end downwards.
2. Upright tin had open end upwards.

The maximum temperature in the inverted tin during overnight incubation was 38.5° C., that in the upright tin was 37.5° C.

The results of this experiment (Table V), show that the vapour, thought to be responsible for the growth phenomenon or complete inhibition of the organisms, was trapped in the inverted tin and in the plugged roll tubes in lethal concentration; the sealed tubes and the plugged tubes in the upright tin were protected from its effects.

Attempts to Reproduce the Growth Phenomenon Experimentally

In an attempt to reproduce the growth phenomenon experimentally, a small bench-type incubator and various air-tight containers were obtained.

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Experiments with Air-tight Containers

Plugged and sealed roll tubes showed normal growth in the incubator room overnight at 38.9°-40.0° C. (thermograph readings immediately outside the tins) in large sealed tins (9½ in. x 9 in. x 13½ in.), containing pieces of wood soaked in linseed oil, and in smaller sealed tins (6 in. x 6 in. x 8½ in.), without wood or oil, in the small, bench-type incubator. Normal growth at 40° C. was contrary to previous observations and this was thought to be due to the long time needed for the temperature inside the sealed tins to reach 40° C. The same tins were incubated as before in two subsequent experiments and a maximum temperature of 39.7° C.-40.2° C. was reached; this was measured by clinical thermometers inside roll tubes within the tins. The growth phenomenon then occurred in the various series of plugged tubes and was considered to be due to the air within the tins having attained a similar temperature to that of the respective incubators.

The possibility of an antibacterial vapour in the laboratory atmosphere was studied and a series of roll tubes were incubated in ground glass stoppered jars. These jars were opened and sealed in an adjacent laboratory and incubated in the incubator room at 40° C. and in the small, bench-type incubator at 39.5-40° C.; these maximum temperatures were checked by clinical thermometers inside roll tubes within the jars. Other jars were also used from which the air was evacuated, after insertion of the roll tubes; these were then filled with air from outside the laboratory. The results of both these experiments showed either the typical growth phenomenon or complete inhibition in plugged tubes in all jars, while sealed roll tubes in the same jars showed normal growth.

The presence of an antibacterial vapour in the incubator room or in the atmosphere of the laboratory, was not established by these experiments.

Experiments with Variations in the Temperature of Incubation

Concurrently with the above experiments using sealed containers, the following observations were made on the effect of varying the temperature of incubation. Series of plugged and sealed roll tubes grew satisfactorily when incubated in the small, bench-type incubator at 36°-36.5° C. When the incubator temperature was raised to 39.5°-40° C. and pieces of wood, soaked in linseed oil, were placed in it, there was either complete inhibition or the typical phenomenon; organisms grew normally in sealed tubes. Although these observations showed that the growth phenomenon could be reproduced in another incubator, they failed to provide any information on its causation.

The temperature of the incubator was then reduced to 36° C., the wood soaked in linseed oil being left in position and, when incubated in these conditions, series of plugged and sealed roll tubes showed normal growth. Subsequently, the incubator was disconnected from the electricity supply and, after removing the wood soaked in linseed oil, its interior was cleaned thoroughly with soap and water. The incubator door was then left open for several days.

The temperature of the incubator was next raised in stages, as shown in Table VI, and three series of sealed and plugged roll tubes were sown and incubated at each stage.

TABLE VI

Growth of Streptococcus pyogenes under different conditions

Temperature of Incubation	Growth in Plugged Roll Tubes	Growth in Sealed Roll Tubes	Growth after 24 hours reincubation at 36° C.
37° C.	Normal	Normal	Not re-incubated
38° C.	"	"	"
38.25° C.	Partial inhibition phenomenon	"	"
39.0 C.	Typical inhibition phenomenon	"	"
40.0° C.	Complete inhibition	Partial inhibition phenomenon	Sparse growth in plugged tubes.
41.0° C.	" "	Complete inhibition	Sealed tubes showed scattered growth.
42.0° C.	" "	" "	Sealed and plugged tubes showed inhibition phenomenon
42.0-42.5° C.*	" "	" "	No growth in sealed or plugged tubes on re-incubation.
44.0° C.	" "	" "	Sparse growth, evenly distributed, in sealed tubes.
44.0-45.0° C.	" "	" "	Sparse growth in sealed tubes.
50.0° C.	" "	" "	No growth.

*Initial incubation period of 48 hours in this case only.

From these results, it appears that organisms in plugged tubes are killed by overnight incubation at 44.0° C., while those in sealed tubes can withstand incubation at 44.0-45.0° C., but are destroyed by raising the incubator temperature to 50.0° C. Incubation of plugged tubes at 38.25°-39.0° C. caused was sufficient for the growth phenomenon to occur whereas variation of the temperature of primary incubation of sealed tubes failed to produce the characteristic growth inhibition.

Several observations made on the comparative increases in readings of thermometers in sealed and plugged tubes during incubation showed no significant differences. A typical result is shown in Table VII.

TABLE VII

Comparative readings of Thermometers during Incubation

Period in incubator	20 mins.	40 mins.	1 hr.	1 hr. 20 ms.	1 hr. 40 ms.	2 hrs.	2 hrs. 20 ms.	2 hrs. 40 ms	3 hrs.	19 hrs. 20 ms.
Thermometer in plugged tube	<35.0°	35.6°	35.9°	36.0°	36.0°	36.0°	36.0°	36.0°	36.1°	36.4°
Thermometer in sealed tube	<35.0°	35.3°	35.7°	35.8°	35.8°	35.9°	36.1°	36.2°	36.2°	36.4°
Excess of upper reading over lower	—	+ 0.3°	+ 0.2°	+ 0.2°	+ 0.2°	+ 0.1°	— 0.1°	— 0.2°	— 0.1°	—

The effect of humidity on the growth phenomenon was studied on a series of plugged roll tubes incubated in two sealed jars. The base of one jar was covered with an inch layer of tap water, and the other had a layer of anhydrous calcium chloride spread over its base. The jars were incubated in the small,

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bench-type incubator, the temperature of which was raised in stages from 39° C. to 41° C. All tubes were fitted with dry, sterile cotton-wool plugs after rolling.

At 39° C. normal growth occurred in those series of tubes in the jar containing water, while tubes in the jar containing calcium chloride showed either partial inhibition or no growth. At 40° C., the tubes in the jar with water showed signs of interference with growth, i.e., colonies were smaller than usual or growth was distributed in irregular patches; tubes in the jar with calcium chloride showed the typical growth inhibition in the 10^{-2} dilution and either no growth or a few colonies in the higher dilutions. At 41° C., tubes in both jars showed very few colonies in the 10^{-2} dilution only. Growth of organisms in sealed tubes, incubated simultaneously in the small, bench-type incubator, showed similar variations to those observed in the plugged tubes incubated in the jar containing water.

The effect of increased carbon dioxide tension on the growth of *Str. pyogenes* was observed in the two sealed jars, the bases of both being covered in anhydrous calcium chloride. Plugged and sealed roll tubes were incubated in each jar. One jar was sealed immediately the roll tubes had been inserted, and a candle was lit inside the second jar before sealing. This jar contained 1.8 per cent CO_2 when measured by a modification of the indicator method described by Salt, 1945.

A series of experiments was performed at incubation temperatures, varying from 39.5° C. to 43.0° C. At the lower temperature, plugged tubes in the jar containing increased carbon dioxide showed normal growth. Those in the other jar exhibited growth inhibition or no growth. The sealed tubes in both jars showed some interference with growth. Incubation at 40.5° C. resulted in normal growth of organisms in the plugged tubes with increased carbon dioxide tension, those in the other jar showed a few colonies in the 10^{-2} dilution,

TABLE VIII

Growth of Streptococcus pyogenes under different conditions

(i) Temperature of Incubation	(ii) Growth in plugged tubes over Calcium Chloride	(iii) Growth in plugged tubes over water	(iv) Growth in plugged tubes over Calcium Chloride with increased CO_2 tension	(v) Growth in sealed tubes
39.0° C.	Typical inhibition phenomenon	Normal		
39.5° C.	„ „		Normal	Partial inhibition phenomenon
40.0° C.	„ „	Partial inhibition phenomenon	„	„
40.5° C.	Complete inhibition		„	Typical inhibition phenomenon
41.0° C.	„ „	Complete inhibition	„	Complete inhibition
41.5° C.	„ „		Typical inhibition phenomenon	„
43.0° C.	„ „		complete inhibition	„

but no growth in the higher dilutions. The sealed tubes in both jars showed poor growth. At 41°C. the plugged tubes with increased carbon-dioxide tension continued to grow normally, the plugged tubes in the other jar failed to grow, as did the sealed tubes in both jars. When the temperature of incubation was increased to 41.5° C. the plugged tubes with increased carbon dioxide tension showed the growth phenomenon. At 43° C. all tubes failed to show any growth. Table VIII shows a comparison of the results obtained in the two preceding experiments with humidity and increased carbon dioxide tension.

Discussion

Partially inhibited growth of *Str. pyogenes* in plugged roll tubes occurred during incubation on racks round the sides of an incubator room, the centre of which gave temperature readings of 37° C. The curious form of growth in tubes affected and the fact that organisms grew normally in sealed tubes, led to a bactericidal vapour being suspected as the cause of this inhibition.

Subsequent investigation disproved this theory. Using a bench-type incubator and varying the temperature of incubation, it was demonstrated that the characteristic inhibition of growth could be reproduced in plugged roll tubes by incubating them at 38.25° C. and above. Inhibition of growth did not occur in sealed roll tubes until the incubator temperature was raised to 39.5° C. Since the incubator room temperature cannot have risen high enough during the initial experiments to cause the inhibition of growth in sealed tubes, faulty temperature control was not at first suspected.

Examination of the results from the experiments with variations in the incubation temperature (Table VIII) indicates the probability that the better growth of *Str. pyogenes* in sealed roll tubes than in plugged roll tubes, is attributable to increased humidity. Any drops of moisture in the neck of the tube are trapped during sealing, while those in plugged tubes can vaporise and diffuse through the plug into the general drier atmosphere of the incubator. Plugged tubes in a sealed jar containing water (Table VIII, [iii]), are in an analogous state to sealed tubes (Table VIII, [v]), and their types of growth at various temperatures correspond closely.

No explanation is advanced for the form of growth exhibited by roll tubes showing the growth phenomenon. It was established (Experiment II) that the appearance of affected tubes was not dependent on the position of the tube, either upright or inverted, during incubation or the presence or absence of cotton-wool plugs.

The steady deterioration in growth of series of roll tubes incubated on ascending racks over a constantly heated radiator in the incubator room (Experiment V, Table III), cannot be explained, but might be attributable to a vertically rising temperature gradient above the radiator in question. That this might be so was shown by recording the maximum temperatures reached by a number of clinical thermometers in plugged tubes placed at levels above the radiator.

During the course of these experiments, it became apparent that individual

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roll tubes in different series could properly be compared only when sown on the same day. Day to day comparisons were not valid unless between several series of roll tubes. This variation in the amount of growth was probably attributable to unavoidable daily fluctuations in the weight and viability of the culture employed.

Many hundreds of roll tubes have been used in these experiments and their freedom from contamination has amply confirmed early opinion on the utility of this technique (Wilson, 1922).

Summary

An unusual growth phenomenon occurring in blood agar roll tubes inoculated with *Str. pyogenes* is described. In typical cases, growth was confined to the medium at the open end of the tube, and various experiments were conducted to ascertain the cause.

No explanation is offered for the peculiar distribution of growth observed in affected roll tubes. Its occurrence phenomenon in roll tubes with cotton-wool plugs is associated with a temperature of incubation exceeding 38° C. At temperatures up to 40° C., similar roll tubes which had been sealed showed normal growth.

Increases in the relative humidity or carbon-dioxide tension permitted normal growth in plugged tubes at higher incubation temperatures: up to 40° C. and 41° C. respectively.

Acknowledgments

We wish to thank Dr. A. W. Stableforth for his advice during the course of this work.

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PLAY IN DOMESTIC CATTLE IN BRITAIN: AN ANALYSIS OF ITS NATURE*

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Review of Literature on Play in General

As a subject for scientific investigation, play in animals seems to have been given comparatively little attention except by Professor Groos (1895), who collected in book form data available at that time. He reviewed the interpretation of play given by the poet Schiller, who attributed play to an

* Presented as an address to the Association for the Study of Animal Behaviour.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

(*Article by Brownlee, page* 48)

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expenditure, in aimless activity, of the energy surplus to that required for the satisfying of needs. Herbert Spencer (1890) also subscribed to the theory that play in the higher animals is due to a superabundance of energy and added that play is a simulation or dramatisation of serious activities. He considered that play did not " subserve in any direct way the processes conducive to life." He gives this definition of play: " Play is equally an artificial exercise of powers which, in default of their natural exercise, become so ready to discharge that they relieve themselves by simulated actions in place of real actions." Groos criticises these authors, pointing out that although superabundance of energy is usually present in the playful animals, this is not always the case, as animals may continue to play until well nigh exhausted. He disposes of Spencer's idea of play being a simulation or dramatisation of adult activities by emphasising that play is manifest in the young *before* the occurrence of those serious activities which play resembles and thus play movements are premonitions of adult movements and not simulations. According to Groos, play, far from being merely a means of getting rid of superfluous energy, is of serious moment to the young animal in that it serves to equip it by exercising and developing the muscles and joints for certain biologically essential activities which it will require to engage in during later life. Groos regarded play as being early manifestations of instincts appearing before the animal really needed them (p. 23). He realised, however, that there could be, in the maturing animal, a difference between play-fighting and real fighting and brought in the idea of " make believe " to explain why playing dogs seldom if ever hurt one another (p. 293). He says when the full-grown dog romps with its master this " make-believe is fully developed and conscious, for his bite is intentionally only a mumbling, his growl pure hypocrisy " (p. 294). He also says (p. 145) " . . . the adult animal, though already well acquainted with real fighting, still knows how to keep within the bounds of play, and must therefore be consciously playing a role—making believe." For an example of such make-belief he quotes Scheitlin: " The Alpine cows . . . fight valiantly, both in play and in earnest; with all their amiability and fondness for one another, they gore and push terribly, yet not in anger or bad temper, but like a lot of boys that fight to exercise their muscles. They will stand for a long time with heads lowered and horns interlocked as if they would never separate . . . their whole mind is concentrated on the push. When one succeeds in shoving the other back, neither seems to care; the loser is not in the least ashamed, nor does the victor show any pride or pleasure " (p. 146). Groos believed (pp. 290-1) that rivalry and the desire-to-master enter into animal play. Groos realised the value of play in enabling animals to win the mastery over their own organs and then over external objects, and he calls such play " experimentation " (p. 85 and p. 290). According to his view the animal has " joy in being able to accomplish something " (p. 290) or " joy in being a cause " (Preface, p. xxiii). He also quotes a number of instances of the influence of fine weather in promoting play (pp. 9, 140, 142, 211 and 261).

Lloyd Morgan (1908) accepted Groos' theory that play served to prepare

the young animal for adult activities, but realised that there are differences between play and the serious activities which play resembles; he also pointed out the value of play to the animal in enabling it to become acquainted with the details of its environment and in learning to deal with it effectively (p. 252).

McDougall (1928) pointed out that the behaviour patterns of play differ from the serious activities which they resemble; for instance, in combat play no hurt is inflicted and no anger is present, nor in flight-play is there any evidence of the fleeing dog trying to escape, and he suggests that play is merely the exercising of the various motor mechanisms in turn; he says: " Play is activity for its own sake, or, more properly, it is a purposeless activity, striving towards no goal. Whence, then, comes the energy that sustains it? The answer is, I think, that the well-fed and well-rested animal, especially the young animal, has a surplus of nervous energy which works through the channels of the various motor mechanisms " (p. 171). He considered that play is not an instinct (p. 170). In discussing the surplus of energy theory of play he says (1948) " the creature is most disposed to play when it is so well nourished and rested that it has a surplus of stored energy. But this is true also of work " (p. 92). McDougall also (1948) in discussing F. H. Bradley's theory that in play there is a measure of self-restraint (a theory similar to Groos' " make-believe " theory) dismisses it as it assumes an impossible degree of complexity in the mental processes of the young dog (p. 94). Colvin and Bagley (1919) define play thus: " An activity performed quite spontaneously and for no conscious purpose beyond the activity itself. Both curiosity and play have been termed ' adaptive instincts ' since they provide the individual in advance of any practical necessity with a set of activities that may serve some useful end. Both play and curiosity are pleasurable activities and the spirit that accompanies them is a valuable stimulus to learning " (p. 50).

Cooper (1942) found that lions played most frequently following an important change in the environment, e.g., just after they have been released from their inside cages into the outside enclosures or on the arrival of the keeper or a person running along in front of their enclosure. He also found play to be somewhat more frequent shortly before pre-feeding activity is begun, more on cool than warm days, less frequent in the middle of the day than in early morning or in the evening, more in females than in males and more in the young than in the old.

Brownlee (1939 *a* and *b* 1950 and 1951) described some of the circumstances under which play occurs in cattle and pointed out that play is essentially the bringing of " those kinæsthetic organs which are not usually exercised in the day-to-day routine of the animal's life, into functional relationship with the terrain, with congeners and with valent moveable inanimate objects "; that it is favoured by good feeding and good weather; that it is further accentuated by arrival of attendants, by itch relief and by œstrus; and that it is inhibited by fear and illness.

Walker (1950) describes how calves, after being taken out of their pens to be weighed, galloped around their pen on their return.

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Beach (1946) criticises Groos' theory by pointing out that to describe play as instinctive still leaves undone the task of determining the stimuli which elicit play, the physiological and psychological processes involved, and the eventual effects produced. He also points out that there is no factual evidence to prove or disprove that youthful practice in play improves adult performance and draws attention to the fact that a dog may show by its behaviour a desire to initiate a game with its human partner.*

Bierens de Haan (1946) also questions whether the animal requires play for practice since normal maturation of the instincts is in itself sufficient to enable the animal to execute the movements concerned with the necessary skill (p. 45).

Kohler (1927) (p. 69) says: "The everyday handling and treatment of objects on the part of the chimpanzee comes almost entirely under the rubric 'play.' If under the pressure of 'necessity,' in the special circumstances of an experimental test, some special method, say, of the use of tools, has been evolved —one can confidently expect to find this new knowledge shortly utilised in 'play' where it can bring not the slightest immediate gain but only an increased 'joie de vivre.' And on the other hand one or other of the manipulations undertaken in the course of play can become of great practical utility." He then described how a chimpanzee used successfully its ability to climb a pole in "play" for the "serious" purpose of reaching fruit placed too high for it to reach by other means.

Objects of this publication.—From the above review it will be apparent that there is no universally accepted theory of the genesis and goal of play, and the object of this paper is to record the manifestations and conditions of occurrence of play in cattle and to atempt an analysis and synthesis in the light of more recent studies of instinctive behaviour and of physiological processes in muscle and the other tissues concerned in play.

Methods

The data recorded in this paper are for the most part observations carried out intermittently over a period of years on cattle of different ages kept under farm conditions indoor and at pasture. These observations have usually been made for the purpose of acquiring knowledge of the general habits of cattle without any special concentration on play. Observations have often been made continuously for several hours and occasionally for periods up to 24 hours. During the past two years or so, cattle, being kept at this station primarily for a study of food and mineral selection, have afforded an opportunity for observing the same individual animals over an extended period. In addition to these purely observational methods the following experimental procedures have been adopted recently and the play reactions studied.

(*i*) Introducing into the loose box straw bales, or in the case of calves, portions of a straw bale wrapped in sacking (straw ball). For one group of twelve young cattle a galvanised water tank was covered with sacking and a

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piece of hay-bale of same weight as the tank and of approximately the same dimensions was covered similarly.

(*ii*) Introducing into loose box, housing calves, a wooden trestle padded with straw and covered with sacking. This trestle was of about the same height as the calves under observation.

(*iii*) Allowing out into exercise yard cattle normally confined in loose boxes. For one group of twelve young cattle part of the cement floored exercise yard was bedded with a layer of well-rotted dung and straw and part left bare.

(*iv*) Observer rubbing with a pocket knife or a coin the neck and/or rump of an animal and then walking off at a quick pace.

(*v*) Touching with one's outstretched hand the head of the animal under observation.

(*vi*) Observer running in the presence of cattle in a field or other enclosure.

(*vii*) Keeping one group of six calves on a relatively poor diet and a similar group on a relatively good diet.

These methods are similar to those advocated by Lorenz (1950) who stressed the value of keeping animals in captivity as a scientific method peculiar to comparative ethology (p. 235).

General Manifestations of Play

The following are the general play behaviour patterns seen in domestic cattle:

(1) Trotting, cantering and galloping with tail at varying angles of elevation (photograph 1).

(2) Bucking with both hind feet jerked up posteriorly and often to one side with an accompanying lateral twist of the hind quarters. The "blow" is almost invariably not aimed at any object.

(3) Kicking with one hind foot either at no object or at objects near at hand; moving objects appear to elicit this latter behaviour most readily, but stationary ones may also serve for this purpose.

(4) Head-butting between two congeners (photograph *vide* Brownlee, 1950); head-butting of attendants, and movable (more rarely immovable) inanimate objects such as water-buckets, food troughs, wheelbarrows (photograph 2), unbolted hinged doors, bolts of doors and tethering rings inset in the wall of the loosebox.

(5) Prancing and setting with head lowered to attendants and inanimate objects may also occur.

(6) Utterance of a sharp "baa-ock" in calves of both sexes; in adult cows also this same sound may be heard during play. This cry contrasts with the drawn-out "baa" indicating want. The muzzle is raised during utterance of this latter sound, but not of the former.

(7) Side to side shaking or tossing of the head (challenge behaviour, *vide* Brownlee 1950).

(8) Snorting (soft and non-vibrant in contrast to the snort of horses) which often accompanies head shaking.

(9) Goring movements with head and horn against objects usually composed of soft material, such as hay or straw bales, hay stacks, lose soil or soil bank, and bedding, the animals very often getting down on their knees to do so. A calf of 37 days old got down on its knees to butt a straw ball and a calf of 29 days old butted a section of hay bale assuming a kneeling position while doing so. Bulls of a year to eighteen months old have been seen to show similar behaviour against a hard object such as a fixed cemented food trough or a jamb. Also a heifer calf seven and a half months old has been observed showing similar behaviour against a fixed cemented food trough.

(10) Pawing loose soil or bedding with fore foot (photograph 3). A calf of about six week old was seen to paw once at bedding in an indefinite manner and this was probably its first or at least an early exhibition of this type of play.

(11) Attempted mounting of their fellows or of attendants or mounting of inanimate objects by animals of both sexes. Photograph 4 shows a heifer calf, seven weeks old, mounting a padded trestle.

(12) Diversifying of the above movements in random fashion. Galloping play may give place to head play; head-shaking, snorting and "baa-ocking" also may often occur during frisking about following head play; playful kicking has been observed after head play with my outstretched arm. When the padded trestle was put into a loose box containing two seven weeks old heifer calves, both scampered around and made head play with the trestle and one mounted the trestle, all within a short period of time. On another occasion one calf mounted the trestle, then immediately afterwards began kicking with one hind foot following by kicking with both hind feet. In a loose box three bull calves of about three months old were being continuously observed and for four hours and 20 minutes they showed only a little play; then without known added stimulus from without all frisked about, head-butted one another, kicked, shook their heads, snorted and attempted to mount one another all in quick succession. On introduction of a ball (straw in sack) into a loose box containing two young calves one of these, 22 days old, head played with the ball, pranced about, set at the ball, galloped around, kicked with one hind foot and "baa-ocked." A calf (eight week old) head played with ball, then galloped around the loose box and "baa-ocked," it repeated the butting of ball, then again galloped around, bucked once and "baa-ocked" twice; it also showed head shaking and snorting. A calf of three months old showed head-butting of ball, "baa-ocking," snorting, bucking, mounting of neighbour all in quick succession and another about 10 weeks old, showed "baa-ocking," snorting, head-butting of ball, and galloping around loose box all within about $\frac{1}{4}$ minute. A heifer calf about three months old attempted to mount another calf and then immediately thereafter galloped around and "baa-ocked." Two bullocks of about a year old galloped, frisked about and bucked and head played when another animal was being driven along a track adjoining their pasture field.

(13) A calf nine months old, while confined in a loose-box, has been observed

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to grip with its jaws the handle of a galvanised water bucket, lift it, then drop it and to repeat this a number of times apparently enjoying making a noise. Young cattle confined in a loose box have been observed, whilst idling, to grasp with the mouth a wire hoop or a metal rail. I do not know whether similar grasping of inanimate objects occurs in unconfined cattle or whether such behaviour occurs only in animals denied scope for their normal activities. A nine and a half months old calf gripped the door bolt between its jaws and moved it about making a noise. A calf of similar age appeared to enjoy moving a loose piece of metal with its horn thus making a noise ("being a cause").

Manifestations of Play in New Born Calves

Within an hour or so of birth, the healthy calf, usually after a number of unsuccessful attempts, has gained the standing position and begins to walk about, unsteadily, investigating the terrain and the various objects within its new environment; it then begins to show quite unmistakeable play movements such as little jumps which, with rapidly growing powers of movement, increase in extent to the prance and gallop. Within a few hours of birth the calf can progress fairly well at all paces, and within a few days it is quite accomplished. A calf only six days old has been seen to give what appeared to be a perfect display of playful bucking. Such activity in the new born calf appears to be spontaneous without any possibility of imitation as the playful calf may be confined from birth in a loose box alone with its dam, which takes no part in play at this period except that it may join in head play in a very passive manner. Three calves four days, seven days and nine days old respectively have been observed head-playing with their dams. A bull calf born in a loose box was heard to "baa-ock" about $3\frac{1}{2}$ hours after birth.

Play in Adult Cattle

Fully adult cows head-play with one another; this is a gentle affair in comparison with a real fight when the animal's full strength is brought into operation. On one occasion a bull of about 18 months playfully trapped and pressed my left leg against the wall of its loose box. The animal was powerful enough to have inflicted serious injury but I realised that it was not applying much force. Adult cattle will also head-play with hay ricks, straw bales, or heaps of loose soil. Playful pawing of soil, etc., with fore foot or digging the soil with the horn may be seen and, quite often by such behaviour, they make an excavation in their pasture field and appear to delight in pawing or head-playing in it, sometimes frisking as they approach to do so. Adult cows also play ecstatically when released after long confinement. A cow seven years old, after having itchy areas of skin rubbed, followed me when I walked away quickly and gave a good display of prancing. Cows may utter a "baa-ock" sound similar to that uttered by calves.

As a rule adult cattle, even although they are being well fed, play much less than well fed young stock, but a group of non-pregnant cows, being fattened after finishing their first lactation, were observed to be very playful.

Conditions of Occurrence

Play does not occur uniformly throughout the life of cattle: the following are the conditions (A) general and (B) particular, under which it has been observed:—

A. *General:* Play occurs

(1) in the young more than in the adult.

(2) in the well fed healthy animal—poorly fed or sick animals play less if at all.

(3) during good weather conditions—cold wet weather definitely does inhibit play.

(4) in animals kept continuously at pasture without any unusual event occurring play is most likely to occur in late afternoon, and not much, if at all during mid-day hours. Play however has been observed around mid-day in cattle at pasture when they saw other cattle being led down an adjoining track.

B. *Particular:* Play will often occur

(1) on being released after a long period of confinement when vigorous play is seen even in adult cattle.

(2) during a period soon after feeding; this is often seen in young calves which are being bucket fed with milk twice daily, and, though not so frequently, in cattle out of doors following afternoon feeding period.

(3) if an observer, after scratching itchy areas of the skin, moves off at a quick walking pace, the animal may follow, playfully kicking up its heels, and may utter "baa-ock." If an observer fondles cattle they will often be induced to head-play with him or perhaps to prance and set to him; this may also occur without immediate fondling in much handled animals. A heifer calf about six months old attempted to mount an attendant when he was grooming it.

(4) in animals gaining access to new terrain when they play immediately or the instincts of hunger or curiosity may have precedence, in which case play may occur after these instincts have been satisfied. Adult animals trespassing to new ground and being driven back towards their accustomed ground have been observed to show frisking and head-play with congeners. Calves trespassing into a strange loose box or a food-store will often playfully gallop off at full speed when they are gently driven out of these forbidden premises into their accustomed yard. Cattle that have started to play in strange premises will often continue to play for a short period on being returned to their own quarters. On occasion calves have been observed to show playful kicking up of heels when moving off after having examined curiously the person of a human stranger. "Baa-ocking" was also heard on one of these occasions. Playful kicking at no nearby object has been observed in an 18 months old bullock immediately after it had inspected the contents of a normally shut-up loose box.

(5) on the arrival of congeners, attendants or of other animals into, or near to, their pasture field or other enclosure where cattle are being continuously kept, e.g. when some cattle were being driven by a dog out of the feeding passage between two rows of calf pens all or nearly all of the calves started to play; also

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on one occasion when, for the purposes of an experiment, I was making frequent entry into and exit from the loose-box which housed a heifer, this animal got down on its knees and playfully rubbed its head on the peat moss litter. A person running in or alongside a field where young cattle are pastured has been observed to induce play in these animals.

(6) on gaining access to moveable, inanimate objects such as wheel barrows, water buckets, feedings troughs, unbolted hinged doors; head-play is then the principal form of play with sometimes concomitant prancing and setting.

(7) on gaining access to hay stacks, hay or straw bales, loose soil or earth bank, the type of play induced being that described above under heading (9) of " manifestations of play."

(8) on imitation of congeners which have commenced to play; one calf gallops off and another often follows suit. Such a phenomenon can be imitated by an observer running away from animals which are in playful mood: the animals thereupon often playfully gallop after him. Calves confined in a loose box have been observed to play on hearing the sounds of playing animals in an adjoining box, even although the latter cannot be seen by the former. Animals in a field have been observed to play, on seeing other cattle play, whilst being moved along an adjoining track.

(9) when bedding is removed; then calves may play on the bare cement but this soon ceases—due presumably to them finding the moist surface too slippery.

(10) when fresh bedding is introduced; scampering around or, much more rarely, getting down on knees and goring the new bedding may be observed. The new bedding may release the hunger drive with no immediate play, but play may occur soon afterwards when the hunger drive has been satisfied.

(11) I have observed heifers, being fed twice daily, to show behaviour similar to that described by Walker (*vide supra.*) when they, after being allowed out in an exercise yard between feeds, are put back into their individual loose-boxes for feeding. These animals are thus playing on the imposition of confinement in contrast to playing on gaining freedom. Cooper's finding of pre-feeding play in lions may be a similar phenomenon.

(12) Head-play accompanied by other forms of play may occur on the introduction of straw bales or, for calves, of part of a straw bale wrapped in sacking. Mounting play or head-play often followed by other types of play may occur on the introduction of a padded trestle (photograph 4).

On first introduction of a ball or trestle to young calves, curiosity is strongly aroused as indicated by the fixed gaze, the forward orientation of the ears, the sniffing and the cautious touching with muzzle or tongue. When curiosity is satisfied, the animal may attempt to butt the object tentatively with the poll and finding the object suitable for play, it may then butt vigorously in play. When twelve young cattle were given the choice of butting either a galvanised water tank or a hay bale of the same weight and approximately the same size, both covered with sacking, it was observed that they might butt either object but most vigorously the bale. Goring, in the kneeling posture often followed this butting of

bale and much more rarely the butting of the tank (21 times bale : 2 times tank).

(13) Cattle confined in loose boxes have been observed to play regularly each day when allowed out with companions into an exercise yard during the time when their individual loose boxes were being cleaned out.

(14) A calf has been observed to butt playfully another which had lain down; it pranced as it advanced to do so.

" Serious " Activities which " Playful " Activities Resemble

All these play movement-patterns are also carried out in a similar though not necessarily identical maner in the performance of some " serious " activity other than play : head-play butting and goring resemble real combat butting and goring; bucking and kicking occur in self defence (young calves do kick in self defence as well as in play); pawing, head-shaking and snorting occur as challenge behaviour; play galloping with tail elevated resembles true flight; play mounting resembles true sex mounting; " baa-ocking " of play resembles " baa-ocking " of extreme terror—a calf two days old uttered such a sound when its dam trod on its hock; and a heifer of about one year nine months of age " baa-ocked " when being restrained. Thus the motor movements performed by cattle during play resemble those which subserve the instincts (1) combat, (2) self-defence, (3) escape, (4) reproduction. The play movements described under sub-heading 13 of " General Manifestations of Play " are not easily given " serious " counterparts; as the head is the cow's manipulative organ in dealing with food and obstructions to feeding it is probable that these movements are the playful counterpart of manipulation.

Explanatory

In the above I have endeavoured to describe the manifestations of play and the conditions of its occurrence. Postulating that play is an instinct I now propose to group these data under the headings of drive, appetitive behaviour, releasers, emotion, consummatory phase and goal and then to piece these components together under the heading " Play Instinct." Before doing so I wish to draw attention to certain " Physiological Aspects of Play." This diversion I consider to be necessary in order to understand the goal of play.

Physiological Aspects of Play

From the description of the play behaviour patterns given above it is apparent that in play in cattle it is those somatic muscle groups serving the purposes of the escape, combat, self-defence and reproduction instincts which are particularly exercised. As occasions for the use of these muscles may occur only at long intervals or not at all in the young and often also this applies to the adult, these muscles would not be adequately exercised except through some other agency : the play instinct is the other agency. These muscles will be referred to in this paper as the " Play muscles."

Krogh (1919) found that in guinea pig muscle only some of the capillaries are open at a time to be followed by closure of these and opening of others and

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that the number of capillaries open in active muscle is greatly increased in comparison with the number open in resting muscle. There is no reason to believe that this is not also so in the muscles of cattle and thus during play the "play muscles" receive an increased blood supply. According to Voit (quoted by Evans, 1941, p. 829) the muscles generally lose 31 per cent of their weight during starvation, whereas the heart loses only 3 per cent. The fact that during starvation the skeletal muscles are being used to a minimal extent whereas the heart is actively working is considered by Evans to be the cause of this difference in percentage loss of weight.

Beattie and Dickson (1943, p. 261), state "The amount of blood supplied to a given part is governed largely by the degree of functional activity, and therefore diminution or arrest of function necessarily leads to a corresponding diminution or arrest of the blood supply. Bones and muscles and muscular organs waste from disuse . . . The muscles in the neighbourhood of an ankylosed joint undergo atrophy from disuse; and the same condition supervenes in muscles, bone, arteries and other tissues in the stump of an amputated limb." From these data it is deduced that play, by exercising and thus vascularizing the muscles, bones and other tissues concerned, is important in the normal development of these organs and in preventing their atrophy after they have developed. It would be expected therefore that in young animals whose muscles, etc., are developing and requiring extra blood supply play would be more in evidence, and also that in the adult, in the absence of adequate exercise in serious activities, a certain amount of play would be needed to prevent atrophy of what has already been developed.

Drive in Play

That there is a drive in play is supported by the following:—

(1) New born calves without activation or example commence to play.

(2) Keeping cattle confined increases the drive.

(3) Calves have been observed to leave food in order to play and to return to that food on being reconfined indicating that the play drive can interfere with the food drive.

(4) Good weather and good feeding increase the drive and the converse decrease it.

(5) Incidents such as the appearance of other animals, the arrival of attendants, the commencement of play by congeners or imitation of such play by human observers, the bucket feeding of calves, having itchy areas of skin groomed and the general fondling of animals all increase the drive. It is apparent however, that it is difficult to be certain always whether a play behaviour reaction is associated with an "increase of drive" or an "increase in releaser" component.

Appetitive Behaviour in Play

Cattle under the influence of the play drive seek out releasers with which they can play; they approach congeners, or hay or straw bales, soil banks,

loose soil in order to head-play or paw; they seek out terrain suitable for galloping and bucking.

Releasers of Play

A feature of play is the multiplicity of objects which serve as its releasers. Terrain, especially new terrain, wheel-barrows, water-buckets, hay or straw bales, hay stacks, loose soil, trestles, congeners, all are valent. As a class these releasers have the property of being such as will permit the animal to exercise a group or groups of the play muscles: terrain for play, galloping and bucking, etc.; straw bales and congeners, etc. for play butting; trestles and congeners for play mounting. (" Releasers as gestalt " will be dealt with in the discussion).

Emotion in Play

There is good reason to believe that cattle do enjoy playing; apparently spontaneously they perform with enthusiasm the various play movements and continue to repeat the performance for a period. If an animal learns that it is able to escape from an enclosure into a play ground, it may, when the opportunity permits and if not otherwise occupied (feeding, etc.), endeavour to do so in order to play. When a playing animal is again re-confined it will often try to regain freedom in order to continue to play. An animal, with which I have played a number of times by outstretching my hand towards its head, has on several occasions taken the initiative and manifested by a toss of the head that it wishes to commence play. Also, cattle regularly approach spontaneously their congeners, inanimate objects, or sometimes attendants and carry out play movements.

It has been illustrated above that many play behaviour patterns are executed in a short period of time and it is unlikely that with each pattern change there is any accompanying emotional change thus implying that one single emotion is maintained throughout play. " Joy in play movements " would appear to designate the emotion.

Consummatory Phase

The performance, through the medium of these releasers, of the described behaviour patterns constitute the consummatory phase. When there is available a highly valent releaser such as a layer of well rotted and firm dung on a terrain for galloping and bucking play or a straw ball for head-play, a feature of the reaction is the spasm of intense effort followed by an interval of inactivity thus suggesting an analogy to orgasm.

Goal in Play

The goal is the physiological benefit derived from the activity of the organs concerned. What endocrine and other bio-chemical changes may be involved would appear to merit investigation.

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The Play Instinct

The above components can be conjoined into one inclusive whole, namely a play instinct.

Definition of Play in Cattle

Cattle have certain neuro-muscular systems, which under activation by the instincts of combat, of self-defence, of escape or of reproduction serve to execute characteristic motor actions. The distinctive features of these instincts is either that their releasers may be absent for long periods (especially in the young), or that the instinct is not mature in the young. In either case long periods would normally occur during which these neuro-muscular systems would not be exercised unless through some other agency.

The animal has another distinct instinct which is mature at birth. Under the influence of its drive, receptory correlates, recognises and accepts as valent either the same releasers (but always when friendly) as serve the first mentioned instincts or other harmless releasers which have the property of allowing these same neuro-muscular systems to be exercised and to produce motor actions similar in pattern to the above-mentioned ones. Whenever this drive is sufficiently active then, by virtue of a normally ever present diversity of releasers, each and all of these neuro-muscular systems may get the opportunity of frequent exercise.

This latter instinct I term the play instinct in cattle.

Play and Learning

It is probable that the new born calf in walking about and playing after first gaining the standing position is acquainting itself with and memorizing the nature of the terrain. A calf has been seen to try butting a piece of straw bale with its head and, presumably finding the piece too small to give sufficient resistance, did not attempt to play with it. Another calf was observed performing exploratory head movements against the edge of a water trough but did not proceed to play. One calf seven weeks old, pranced and set to the corner of its food trough and tossed its head as if to butt it but did not do so. Another calf atempted to butt a straw bale but did not at first succeed in making actual contact. On another attempt it made contact and then played vigorously.

As a result of these exploratory movements the animal presumably decides whether or not a terrain or an object is suitable for play, and proceeds accordingly. There is reason to believe that during actual play further messages from the kinæsthetic nerve-endings reach the central nervous system and that the animal is continually memorising these messages and thereafter it can choose for play suitable explored terrain or suitable explored objects or congeners. The necessity, to the animal, of exploration of terrain by walking and playing is well illustrated by the behaviour of young cattle which have been confined in a loose box from early life until some months old. Although there is individual variation in boldness, such calves, as a class, will refuse to leave their place of confinement when first given the opportunity to do so and first explore, with all the curiosity

senses alert, the portal to the outside world. After a number of exits they proceed with confidence. Similarly, when trestles or straw balls are for the first time introduced to young calves, there is exploration with all the curiosity senses before play commences. If the same object be re-introduced at a later period the curiosity response is less or absent.

The following are possible examples of cattle learning from the results achieved during play:—

(1) When calves are housed in a loose box in which only a part of the floor is bedded, they learn either not to play on the unbedded part which often becomes wet and slippery or to progress carefully over it. When out on a cement-floored exercise yard in which parts of the floor surface may be wet, they either jump over these parts or cross them carefully; when part of such an exercise yard was purposely bedded with a layer of rotted straw and dung, calves were observed to gallop, prance and buck vigorously on the bedded part, while on the unbedded part they progressed with caution. The intensity of play on the bedded part increased as the animals gained confidence on being allowed repeated access to this terrain. This process would appear to correspond to the "facilitation" phenomena described by Walton (1950) as occurring in copulation behaviour in young bulls.

(2) Heifers, being fed with hay in a yard and finding difficulty, due to congestion by other animals, in gaining access to hay were observed to mount one of these others apparently realising that when they do this the mounted animal will move away and thus leave a space for the mounter. This was probably learned when these animals mounted each other in play during calfhood. A calf ten weeks old mounted another calf which was obstructing its access to its milk bucket.

(3) One of our heifers when about two and a half years' old, learned to open loose-box doors by pushing back the bolt with its muzzle and then opening the door by pushing it with its head. As cattle may head-play with the bolt and may by accident push it free, this animal probably learned the connection between the movement of the bolt and its ability to push open the door. On the other hand, as cattle may rub the head against a door bolt during their grooming, the primary openings may have occurred in this way rather than during play. Incidentally, this animal could open loose box doors confining other animals and also has been observed to try to open a similar door leading from exercise yard into a hay and straw store.

Survival Value of Play

The data presented in this paper support the view which has been put forward by previous authors that play serves two purposes: (1) it exercises and strengthens the muscles, tendons, ligaments, bones and joints involved in play; in the immature animal these organs are thereby trained and are then ready for use in those corresponding serious activities which play behaviour outwardly resembles. (2) By playing the young animal becomes acquainted,

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from impressions received from its kinæsthetic sense organs, with properties of its environment and thereby can attack or escape with confidence in its knowledge of its terrain and the experience gained by play fighting with inanimate objects and friendly congeners will be valuable when attacking alien congeners and also predators.

Individual Variation in Play

Calves in playful mood do not respond alike to the same type of releasers; for example when a straw ball was introduced on several different occasions into the loose-box where two calves about three months old were kept, one calf regularly head-butted the ball, whereas the other butted the ball a little on one occasion only; this latter calf though not playful with the ball would gallop ecstatically when allowed out into the exercise yard. Of another similar pair of calves one would mount the padded trestle regularly but head-played only a little with it whereas the other never mounted the trestle but butted it actively. There is a sex difference in that young bulls combat-play more than do heifers of a corresponding age. The greater development of neck muscle in the bull is probably related to this behaviour. An age difference is apparent in that, whereas in the young calf galloping, bucking, and kicking are the most prominent features of play, in the adult head-play is the most frequent form.

Influence of Feeding on Play

Six calves of about eight months of age, previously well fed and playful, were put on a poor diet of two pounds of hay between two animals and oat straw *ad lib* daily for three months; six calves of the same age kept under similar conditions, except that their diet consisted of concentrates and hay, acted as controls. In order to observe their play reactions, the twelve calves were allowed out periodically into an exercise yard, a section of which was bedded with dung and straw. Also they were observed in their loose boxes for a number of periods each of several hours; at each period a pair on the poor diet and a pair of controls were kept under observation. All six animals on the poor diet showed less vigorous play than those on the good diet, especially towards the end of the experiment, by which time three of them played just a little and the other three did not play at all. The movements generally of these six calves were noticeably slower than those of the controls. When at the close of the three months, a diet similar to that of the controls was given, the increase in play of all six calves was well marked.

Discussion

The evidence given above indicates that play has all the components of a single instinct—drive, appetitive behaviour, releasers, emotion, consummatory phase and goal. Groos, on the other hand, regarded play as an early manifestation of a number of instincts before they were actually required, but such

a teleological interpretation of play does not agree with present-day views on instinctive behaviour. As pointed out by McDougall, Groos did not resolve the very important difficulty of reconciling the differences between play behaviour and those adult activities which resemble play. He brought in the improbable concept of "make-believe" to explain the difference between play fighting and real fighting. So far as cattle are concerned, they could be said to show "make-believe" in that, when head-playing with congeners or attendants, they exert much less force than they would employ in real combat. Also, an animal highly placed in the herd hierarchy may play with one lowly placed. Indeed the more lowly placed animal during play may "attack" with head the abdomen or hind quarters of its superior in addition to head-playing with it. If, as has been done in this paper, one accepts the proposition that play is an instinct quite separate from the instinct of combat then no *a priori* implication is made that play combat and real combat are identical and thus there is no need to postulate make-believe.

Inability to apperceive a goal being reached in play would appear to have brought McDougall and others to the opinion that play is not an instinct. When cattle play there may be outbursts of muscular activity which are here regarded as the consummatory phase of the play instinct; yet at the end of such outbursts there is no essential change in the relationship of organism to environment: the playing animal has ingested, or otherwise received into itself, nothing from the environment, nor has it liberated any secretion or excretion; the straw balls or the congener may still be intact and approximately in the same position relative to the player after an outburst as before. Thus one would agree that no goal effecting a change in the relationship between the animal and its environment has been reached.

The view adopted here is that the goal is to permit "play-muscle" activity with resultant increased tone and increased vascular supply, and thus a tissue-trophic change within the organism is brought about. This physiological interpretation of the genesis of play is arrived at by deduction as follows:—

(i) Play is most prominent in well-fed young cattle, that is, at a time when the cells in the play neuro-muscular systems are rapidly developing and requiring most food, and at the same time the animal has a reserve of food potentially available to these cells.

(ii) The muscle capillaries during rest are open only some at a time and it is probable that rapidly developing muscle cells would be inadequately nourished were there not some means of increasing the blood supply to them. This is done by exercise during play.

(iii) Muscle groups, concerned with the performance of frequently occurring activities and presumably sufficiently exercised thereby, are not used specifically in play, e.g., the muscles used in mastication, in roaring when in need, in lying down or rising up, or in walking in search of food.

It has been pointed out above that the animal, having played, is as a result better acquainted kinæsthetically with the environment, and it might be argued that this is the primary goal of play. This would be equivalent

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to making play a sub-division of the curiosity instinct. Against such a view are the following:—

(i) Not only does the playing animal exercise the muscles pivoting on articles in the environment, but also other muscle groups such as those producing head-shaking, snorting and baa-ocking, which do not at all contact articles in the environment and whose activity therefore does not lead to any increase in knowledge of the environment.

(ii) The play drive once released in a new environment will often continue for a short time on the animal's return to its old environment.

(iii) The "facilitation" phenomena described above.

(iv) Cattle at pasture often make a hole in the ground by playfully digging with the horn or pawing with the fore foot and enjoy returning to this hole for more play of this kind. This is obviously not increasing their acquaintance with their environment.

(v) If into a loose-box, with which the contained calves are familiar, a straw ball is introduced, not only is head-play with the ball induced but also perhaps galloping around, "baa-ocking," head-shaking, kicking or bucking, so that play has diffused far beyond the acquisition of an acquaintance with the properties of the newly introduced ball.

(vi) In a constant environment the manifestations of curiosity (starting at, smelling, etc.), soon die down, whereas play may continue long afterwards indicating that play is an instinct apart from curiosity.

(vii) Adult cattle head-play with each other though they must have been for a long time previously familiar, both by previous play or perhaps by fighting, with the properties of a congener pushing with its head.

For these reasons it is concluded that the goal of play is not the acquisition of kinæsthetic acquaintance with the environment. However, as already pointed out under "Play and Learning," the animal while playing is acquiring as a *derived* gain increased kinæsthetic knowledge of its environment.

In several of the records described above under the heading "Conditions of Occurrence (B)" there had occurred an incident which probably excited the curiosity of, and brought pleasure to, the animal in the otherwise monotone of its life, and such an incident does appear, to use everyday language, to brighten the animal up and it begins to play. It appears to me difficult to be certain of the sequence of events here. One is reminded of Archimedes, elated with his discovery, running naked down the street and shouting. Shakespeare drew attention to the effect of such incidents:—

> And when the mind is quicken'd out of doubt
> The organs though defunct and dead before
> Break up their drowsy grave and newly move
> With casted slough and fresh celerity.
>
> K. Henry V.
> Act IV, Sc. 1.

According to Ewen (1945) a pleasurable effect gives *inter alia* increased muscle tone (p. 23). Young (1943) says: "Joy is typically a pleasant state in which there in smiling, laughing, and excessive random activity. The joyful child, when promised a trip to the circus, jumps up and down, whistles or sings, laughs, claps his hands in anticipating the event, etc." (p.323).* The effect of feeding of calves, of relief of itch or social stimulation in the form of playful attention from congeners or human observers on the play drive may have a counterpart in the human subject. Young says: "With the infant and young child, smiling and laughing tend to occur under specific conditions such as these: (1) When an appetite—hunger or thirst—is satisfied; (2) when there is relief from various discomforts, such as those produced by a damp diaper, a pin pricking the skin, internal colic pains or other aches; (3) certain positive stimulations—coloured objects, rattles, warm contacts, sweet tastes, and especially *social* stimulations from parents, or other adults; (4) when the free movements of play and rhythmical dancing are made" (p. 167)* Groos considered that the playing animal experiences joy in being a cause or joy in being able to accomplish something. I also have adduced evidence that cattle enjoy play. These considerations lead to the question as to whether enjoyment in itself is the motive for play. If this should be the case then the purely physiological theory of play, advocated in this paper, would be only partly valid as the play drive would then be governed by a desire for enjoyment which might not be related to a physiological need. This aspect of instinct (psychological hedonism) has been discussed by McDougall (1948, p. 313) who pointed out that the pleasure is derived from the attainment of instinctive ends and that it is the instinct which is primary. Agreeing with McDougall, I would say that in the case of play it is the needs of the play muscles, etc., which is primary and that the pleasurable accompaniment of play is secondary and serves to ensure the periodic repetition of play as a desirable activity. It may be pointed out here that play tends to be most prominent in calf-hood and to decrease markedly even in early adult life, whereas if pleasure were the goal one would have expected the reverse to occur with the animal's increasing mental association of play with pleasure.

Regarding Groos' theory of play being a means of exercising and developing muscles, tendons and joints, the above indicates that I agree with this. So far as cattle are concerned there is a point which ought to receive attention here, namely, that the calf is able at a quite young age to perform with skill many play movements; so skilfully indeed that it is doubtful if practice during the animal's lifetime improves the *quality* of the performance to any appreciable extent and yet play continues long after this degree of excellence has been reached. The emphasis should be put on play as a means of increasing the *power* due to the increased development of the muscles, etc., as distinct from an increase in the *skill* in performance.

* Reprinted, with permission, from "Emotion in Man and Animal," by P. T. Young (copyright 1943: John Wiley & Sons, Inc.).

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So far as cattle are concerned, Groos would appear to me to be wrong in considering that rivalry enters into play. One animal invites another to play with it and certainly does not exert its utmost effort to overcome its playmate, else the weaker playmate would have to give up play, which is probably the last thing either player desires. Cattle at different levels in the herd hierarchy may play with each other. It would appear probable that in play with congeners the animals welcome resistance and their aim is not to disperse that resistance but to exert only so much pressure as will invite a corresponding pressure in return. Young calves were observed to head-play with their dam, the dam merely tensing its head without applying any active pressure. Rivalry obviously does not enter into such a case.

As indicated above, a feature of play is the multiplicity of objects which serve for the animal to play with. It is noteworthy that no matter whether a newly-introduced play object permits specifically of head-play or mounting-play there is a marked tendency for many or all of the play movements to occur in quick succession. Whether this phenomenon should be interpreted as being due to diffusion of stimuli from one centre to another within the animal's central nervous system or whether the newly-introduced object causes the formation of an entirely new gestalt so that all the various objects (including congeners and terrain) now become highly valent for play is not clear.

Puberty in the calf occurs at 4 to 8 months of age (Rice, 1942, p. 180). Long before this age the calf shows mounting of its fellows but these invariably take avoiding action so that mounting is only partial or hurried. When a young calf mounts a dummy, on the other hand, the pelvic movements, typical of the adult, are seen. I have observed young male calves and lambs mounting others and there is no evidence of erection of the penis. In the case of a colt foal, only a few days old, in which species the penis is clearly visible, this was seen to be flaccid when it mounted a filly foal and performed rhythmic pelvic movements. Thus mounting in the young calf resembles true sex mounting except that the genitalia are not involved. Walton (1950) quotes Beach as saying that copulatory patterns appear long before puberty, may last until old age and even persist for an indefinite period after castration. I have observed mounting behaviour by bullocks both of other bullocks and of a female in œstrum. Walton also states (and I agree with him) that œstrous, diœstrous and mounting by castrated males, diœstrous or pregnant females is motivated by play or by sex. As the immature or the diœstrous female tries to avoid being mounted, probably the urge to mount becomes to some extent stultified due to repeated lack of success. With the œstrous cow the case is different, the opportunity for either play mounting or sex mounting being presented and availed of by animals of differing sex status.

When one considers that there is a great tendency for many play behaviour patterns including mounting to occur in quick succession in the young thus indicating a common emotion and that in the adult combat play occurs without anger and flight play without fear, there does not appear any justifica-

tion for concluding that lust motivates the mounting behaviour of the dioestrous the pregnant or the castrated. I propose that this behaviour should be classified under play.

Spencer regarded play as simulation or dramatisation of serious activities. Whether play or "serious activity" was first in phylogenesis, I do not know; in bovine ontogenesis, play begins within a few hours of birth, and it is play and not serious activity which is mainly responsible for the early training of the play muscles. Thus one is not justified in saying that play is simulation or dramatisation of serious activity for, as Groos pointed out, play precedes these. Spencer's concept of "powers . . . become so ready to discharge that they relieve themselves by simulative actions in place of real actions" might, however, be used in classifying play if one substitutes for "simulated actions" "para-activity," which term would have the merit of implying that play is an *independent* phenomenon though certain aspects of its behaviour patterns might be similar to those of combat, self-defence, escape and sex.

Summary

(1) The manifestations of play in domestic cattle and the conditions of its occurrence have been described.

(2) The theory is proposed that play in cattle, instead of being, as Groos thought, manifestations of a number of instincts before they were actually required for serious purposes, is in fact one instinct with its own drive, releasers, emotion, consummatory phase and goal.

(3) The goal of play is not to be found in the animal's environment but is tissue-trophic and serves to exercise and thereby maintain tone and adequate vascularisation of the play muscles and the other structures involved in play behaviour.

(4) A derived survival value of play is the familiarising to the animal of certain items in its environment in relation to its play movements: play continues in an environment long after this familiarity has been established.

(5) There is variation in the type of releaser to which individual cattle respond.

(6) Sex and age modify the manifestations of play.

(7) Rivalry, if it operates at all in play in cattle, is only a minor motive.

(8) Whether the tendency during play for the behaviour pattern to switch in succession from one type to another should be interpreted as being due to diffusion of stimuli from one centre to another within the central nervous system or whether the releaser of play is a gestalt and all the play items in that gestalt become valent together is discussed.

(9) The tendency for a bovine animal to play is influenced by its state of nutrition.

(10) The classification of mounting by bullocks and by dioestrous and pregnant females is discussed and reasons for putting this behaviour under the rubric of play are given.

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(11) The term para-activity is suggested for play to indicate that, although play resembles in its behaviour the patterns of combat, self-defence, flight, and sex mounting, it is in fact an entirely separate phenomenon.

Acknowledgments

I am indebted to Dr. W. S. Gordon for allowing me opportunity and facilities to carry out this work; to Professor A. V. Hill for information and discussion on the vascular supply of muscles and the probable influence of play on neuro-muscular development and adjustment to environment; to Mr. F. Summerfield for the photographic illustrations.

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Fig. 1

Fig. 2

Fig. 3

Fig. 4

(Article by Tucker, page 69)

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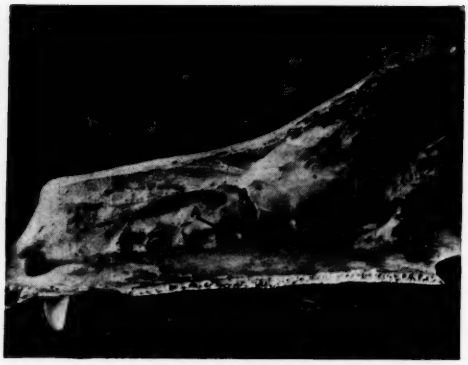

Fig. 5

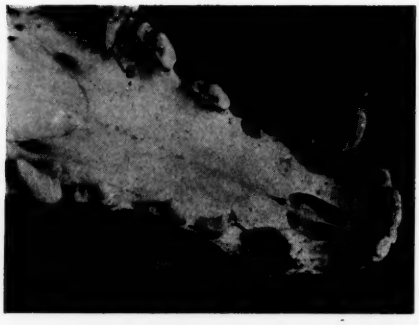

Fig. 6

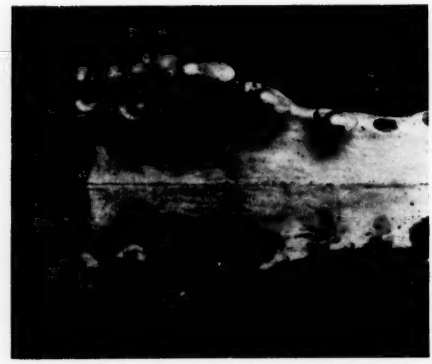

Fig. 7

(*Article by Tucker, page 69*)

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ORTHOEVOLUTION (ORTHOGENESIS) IN THE CANINE SKULL

By RICHARD TUCKER

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THE skull of Canidæ is characterised by a scarcity of bony material and a tendency to modifications such as those peculiar to pekinese, bulldogs and greyhounds. The pekinese-bulldog type is said to be the result of chondrodystrophic change, a mutation which is dominant. Among the Canidæ, the most elongated skull is the cranium of the greyhound. Orthogenetic changes in the skulls of different animals have been recorded, one of the commonest examples being *Babirussa babirussa.*

Associated with the shape of the greyhound's skull is the well-known carnivorous instinct depending for its satisfaction upon appropriate dentition.

This investigation was suggested by considering how these complex factors influence the structure of the skull and, in particular, the line of development of the greyhound's cranium.

The lateral face of alveolar process in the typical canine skull shows the dental roots covered by alveolar walls (Fig. 1). The interradical impression is moderately deep and rather narrow. In fact, it is present only between the roots of P_4.

In the greyhound (Fig. 2*a*—The dental root exposed. *b*—The inter-rootial fossa. Fig. 3*a, b, and c*—Exposition of roots of M_1.), the alveolar walls are as thin as paper, and sometimes the dental roots are actually exposed. The thin lamellar maxilla forms a deep and wide interradical impression. The most often exposed is the apex of the M_1.

From the median aspect (Fig. 4*a*—Nasal cavity dental roots. Fig. 5*a*—Exposition of anterior dental root of P_3.) the dental roots form a line of permanent bulges. The dental roots are much thicker than the maxillar bone. Fig. 6 (*a*—The alveor hypoplasia of C. *b*—The superficial position of the median roots of P_4) demonstrated one of the canine alveoli. In the medial wall a large hole is present and the root is only partially covered. The medial root of the P_4 (Fig. 6 and Fig. 7*a*—Median root of P_4 in the greyhound,) is usually situated superficially. Only the apical part of this root is sunken in the bony mass.

The measurement of the thickness of the maxillar bone layer and the dental roots give the following figures in the average greyhound:

	Thickness difference
Canine alveolus — 6 mm.	
Postcanine maxillar wall — 1 mm.	5 mm.
Median and lateral roots of P_4 — 10 mm.	
Interspaces between roots of P_4 — 4 mm.	6 mm.

Conclusions

The greyhound skull is characterised by the inequality between the thickness of the maxilla and the size of dental roots. The roots are thicker than the bone, and this causes the superficial position of the dental roots which often lose their bony support. This applies particularly to the roots of—C—P_4 and M_1—which are often uncovered. The alveoli and the dental roots in the nasal cavity form the line of swellings. The skull evolved into a form displaying the loss of steady alveolar support, especially in the most functionally important teeth—C—P_4—M_1. Further selection in this direction may cause biological disadvantage leading even to disability in survival.

Acknowledgment

I wish to thank Professor T. K. Ewer for his interest and kindness in reading the manuscript.

Abstract

The skull of the greyhound is characterised by the inequality between the thickness of the maxilla and the size of the dental roots. The skull evolved into a form displaying the loss of steady alveolar support. Further selection in this direction may cause biological disadvantage.

SURRA: A CASE HISTORY

By SAEED ASGHAR, B.V.Sc.(Punjab)

THE disease "Surra" is of regional and seasonal occurrence. It is observed most frequently in low-lying, marshy areas, and it is most prevalent during the months from July to November. The causal parasite, *Trypanosoma evansi,* is monomorphic and transmitted from animal to animal through the agency of biting flies belonging to the families Tabanidæ and Stomoxiæ. The transmission is mechanical and the parasites die after 24 hours if they remain in the proboscis of the insect. Cattle, buffalo, deer and zebras are considered to act as reservoirs but do not manifest clinical symptoms.

It appears almost certain that the curative action of any trypanocidal agent depends on its direct action on the parasite. A permanent cure can be effected only with the aid of natural antibodies; these antibodies are elaborated by the body soon after the injection, and if, during their development the parasites are kept in low concentration by repeated doses of a parasiticide, the antibodies in the end can complete sterilisation and cure. The best results are obtained by a dose of the parasiticidal agent that is just sufficient to destroy all parasites accessible to the circulatory ions of the agent. Any larger dose is merely more

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toxic to the tissues. I have treated many cases of "Surra" with Antrypol (I.C.I.) and I append a case record.

No. 10.—Dated 7/7/51. Indian-bred chestnut gelding, 6 years.

History

Clinical signs.—Œdematous swellings under the abdomen and marked progressive emaciation with staggering gait.

The animal was dull, and its coat was rough. There was profuse salivation and the right side of the lower lip was hanging down.

Pulse 42, respiration 18, temperature 103.4 deg. F. The bowels were constipated, and the conjunctivæ anæmic and showing petchiæ. Blood examination revealed *Trypanosoma evansi.*

Treatment.—Antrypol (I.C.I.) in 10 per cent solution was injected intravenously on two occasions; 7/7/51, 4 gm.; 14/7/51, 2 gm.

The patient was discharged as cured on 22/9/51.

Discussion.—The late Dr. J. T. Edwards, when working on trypanosomes in India, found that when the parasites were absent from the blood the number increased in the cerebrospinal fluid. He maintained that in order to effect a radical cure or to sterilise the entire system the parasiticide should be injected intrathecally. He used Bayer's "205" with remarkable results. He stated also that a single dose of Naganol could effect a cure, but relapses were quite common.

Bayer "205" or Naganol remains in general circulation for a long time, apparently about two months, in sufficient concentration to exert a trypanocidal action which progressively increases with each parasitic relapse. It is recommended as follows:—

(1) Injection of Naganol 10 per cent 50 c.c. intravenously; injection of Naganol 0.1 per cent 20 c.c. intrathecally. Repeat after two weeks. Or inject Naganol 0.1 per cent 20 c.c. intrathecally.

(2) Single injection of Naganol 4 per cent 100 c.c. intravenously gives good results and is repeated after a month's interval.

Naganol is useful as a prophylactic agent in badly-infected districts.

Tartar emetic displays intense trypanocidal properties and is tolerated safely by the animal when administered intravenously in the first instance in small doses. It can be increased gradually afterwards. It is commonly employed in combination with Naganol. Taylor recommends it in the following way: 1st day, Naganol 1 per cent 100 c.c. intravenously; 5th day, tartar emetic 1 per cent 100 c.c. intravenously; 10th day, tartar emetic 1.5 per cent 100 c.c. intravenously; 15th day, Naganol 1.5 per cent 100 c.c. intravenously; 20th day, tartar emetic 2 per cent 100 c.c. intravenously; 25th day, tartar emetic 2.5 per cent 100 c.c. intravenously; 30th day, Naganol 2 per cent 100 c.c. intravenously.

The disadvantage in the Naganol-cum-tartar emetic treatment is the repeated injections which are inconvenient to the animal as well as to the operator.

During World War II and after, when Naganol was not available, the

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I.C.I. "Antrypol" or "Suramin" gave good results in the cure of surra and also when used as a prophylactic. It is said that "Antrypol" combines with alpha-globulin of the blood, thereby the slow excretion and prolonged action of the product is guaranteed. It obviates the repeated injections and shortens the period of treatment. It is recommended as follows: 1st day, Antrypol 10 per cent 40 c.c. intravenously; 7th day, Antrypol 10 per cent 25 c.c. intravenously; 14th day, Antrypol 10 per cent 25 c.c. intravenously.

REVIEWS

NOTES ON ANIMAL HEALTH AND INDUSTRY FOR AFRICANS, by D. E. Faulkner, D.V.M., F.R.C.V.S., Dip. Agric. Produced as a Government Publication by the Government Printer, Niarobi, Kenya. 327 pages plus v. 66 illustrations and 6 appendices. Price 5s.

THIS paper covered handbook has been produced to meet the requirements of Africans on a wide range of subjects dealing with certain aspects of general agriculture, animal husbandry, animal health and certain industrial processes arising from animal products. It should prove a most useful reference book for the better educated native and those who are concerned with the supervision and instruction of the indigenous farmer as well as the colonist who may engage in farming and related occupations in the vast continent of Africa and indeed, in some respects, in other parts of the world. It will undoubtedly find a place in schools and technical institutions concerned with the instruction of the more progressive inhabitants.

The book ranges over a variety of subjects and the text is not a continuous narrative but a series of numbered paragraphs of simply stated facts, which should be eminently suited to the native mind. The author is to be congratualted on taking the advice of educationalists experienced in teaching natives in Africa which might well be adopted as a pattern for similar publications elsewhere in colonial empires. The author acknowledges the help and advice which he has received from a number of colleagues of eminence in their particular professional spheres.

Included in the work are an introduction to the elements of general agricultural methods, the general principles of veterinary anatomy and physiology, the feedings of animals and conservation of feedingstuffs, an introduction to various diseases of cattle, sheep, goats, pigs, poultry, rabbits, the working ox, breeding of cattle, dairying notes on the donkey, camel, poultry, ducks, turkeys, rabbits and bees. The horse, however, appears not to have found a place in the economy of African farming.

No less than twenty-two pages are devoted to hide production which is such an important source of income to the African colonies. A list of works

of reference for further reading is given and this includes not only many well-known text books of world wide repute but, we are pleased to note, the publications of the Young Farmers' Club, the booklets of which are more likely to be of use to natives desirous of further instruction than the standard scientific works.

One would like to have seen better reproduction of the numerous illustrations. Many of the photographs are excellent but would have proved more useful had they been larger, whilst some are hardly likely to convey any useful knowledge to the native (c. f Fig. II). Some of the line drawings are indifferent and would have better graced such a mine of useful information had they been prepared with more care.

No doubt the need to keep the cost to the native purchaser at the lowest possible level has been constantly in the mind of the publishers but we feel that, notwithstanding, the book merits a more durable cover.

FROM POINT TO POINT, by John Board. London: Christopher Johnson. Price 18s. net.

THIS is the autobiography of a man who has been fortunate, or unfortunate to have lived in a time of great change in the mode and tempo of life. The change has wrought havoc with many things and customs which were thought to be so substantial that they could endure for ever.

His experience is not unique for there are many of his generation who could speak in similar manner. Two great world wars have ensnared them. The first ruined their youth, the second destroyed what they had managed to salvage from the wreck. When John Board was born the horse was "King" and the internal combustion engine only a small cloud on the distant horizon.

In spite of a complete change in his own prospects and circumstances the author has been able to orientate his life so that he could enjoy his sport and indulge in his passion for horses. As a young man he went tea planting in Ceylon and he was beginning to enjoy the social life of that island when Great War I arrived. He came home to join the forces and strange to relate he became an infantryman, but in those days there were plenty of horses in all branches of the army, and his service on Salonica front was sweetened by the cults of horse and hound. Sometimes they hunted under the eye of the enemy.

After the war he joined the "Sporting" staff of the *Times,* and as his editor insisted on his men going out from place to place to see what was going on he covered a variety of sports and made a wealth of friends. Incidently he became a golfer of top rank.

He covered "Polo" and went to America in 1939 to report on the international game. Then came World War II and more military service. In 1946 he made a new start in civilian life reporting on shows showmen, polo and the Olympic equestrian events.

The author tells his story with a verve that will appeal to all sportsmen and particularly those of the horse fraternity. He has acquired considerable

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skill as an artist and the many illustrations in this book indicate that he has a profound knowledge of shape, form and action in horse and hound.

BIOLOGY AS A CAREER.

THIS booklet of 32 pages, published by the Institute of Biology* at 2s. 6d., contains the essential material gleaned from two symposia on biology as a career arranged by the Institute in 1952. The editor, Dr. G. E. Fogg, must be congratulated upon his competent presentation of the many aspects of this subject.

The introduction deals with the nature and scope of the subject, the complexity of biological material, and its practical and cultural value. Whilst it is not the intention of this booklet to deal with careers in farming, horticulture, medical or veterinary practice, nevertheless it makes a thorough analysis of the numbers of biologists employed in these fields, the types of work which they do and their remuneration.

The great value of the booklet resides in the fact that it starts with school and the choice of subjects, following this with advice on studies at the University either for academic or for applied biology. It reviews the combinations of subjects required for teaching at schools or University, or for research academic or applied. It considers post-graduate training for higher degrees, for teaching, or for employment in industry, government departments or the various institutions controlled by the Medical and Agricultural Research Councils.

There follows an analysis of the opportunities for professional biologists in schools, universities and other educational institutions: the numbers and types employed in Medical Research, Agriculture and Horticulture, Hydrobiology and Fisheries, Forestry, Nature Conservancy, Scientific Civil Service, Industry, Brewing, Pharmacy, Pest Control, the Commonwealth and Colonies.

An estimate of present and future demands for biologists is given, together with rates of pay. A table of comparative rates of pay in pounds for age completes the analysis and the booklet concludes with a bibliography and the addresses of the institutions and government departments mentioned in the text.

All those who desire to take up a biological career should read this booklet.

*Tavistock House South, Tavistock Square, London, W.C.1.

ERRATA

The title of the paper by J. N. Oldham and W. P. Beresford-Jones which appeared on page 29 of the January issue should have read as follows:— Observations on the Occurrence of *Cnemidocoptes pilæ* Lavoipierre and Griffiths, 1951 in Budgerigars and a Parakeet.

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ANDREW SPREULL

OBITUARIES

ANDREW SPREULL, D.S.O., T.D., D.L., M.R.C.V.S.

His many friends were sad when they heard that Andrew Spreull of Dundee had died on December 31, 1953, at the age of 76 years. He was one of a generation now ebbing away, the men with a profound knowledge of horses who by their skill and integrity brought honour to the profession. His great grandfather, Andrew Spruell, was a farrier at Neilston and record shows that he was married on March 17, 1809. Andrew's second son, James, became a Veterinary Surgeon and subsequently took the diploma of the R.C.V.S. He practised at Milngavie, Dumbartonshire, until his death on May 22, 1873. James's eldest son Andrew, went to the Dick College and subsequently started practice in Dundee in 1868. Andrew, who has died recently, joined his father in the practice in 1902 and in turn the practice is being carried on by his son Dr. James Spruell.

These facts must make the Spreull family one of the oldest to be continuously employed in Veterinary practice and in this respect the family must compare with the Buckinghams of Norfolk and the Bovets of Somerset.

Andrew Spreull was born at Dundee on August 10, 1877. He attended the local High School and then went to the New Veterinary College, Edinburgh, entering in the year 1896. He joined the Fife and Forfar Yeomanry as a Trooper on June 1, 1897. He joined the Service Squadron (26th Coy. Imperial Yeomanry) in December, 1899, and was promoted to the rank of Farrier Sergeant. This change was made so that he could serve in South Africa, for the Boer War was then in progress. It meant, however, that his veterinary studies were interrupted. He served in South Africa from February, 1900, until May, 1901, and was mentioned in despatches by Lord Kitchener in November, 1900.

He resumed his studies in 1901 at the Royal Veterinary College, London, and qualified M.R.C.V.S. in July, 1902. He gained honours in the final examination and was awarded the Ralli Memorial Prize. After joining his father in practice in Dundee, he attended, in 1904, the post-graduate course conducted at the R.V.C. by Sir John McFadyean. His service in the Yeomanry and in the field gave him a liking for the military art and so he continued in the Service as a Sergeant in the Fife and Forfar Yeomanry after the South African War. He was gazetted Veterinary Lieutenant on June 18, 1904, and Veterinary Captain on April 1, 1908. On August 4, 1914, he was mobilised with his regiment, the Fife and Forfar Yeomanry and in due course proceeded to France, being appointed O.C. of the 4th Mobile Veterinary Section in 1915.

Promoted to the rank of Major he was appointed D.A.D.V.S. of the 55th Division on January 5, 1916, and was mentioned in despatches by Sir Douglas Haig on two occasions, November 3, 1916, and April 9, 1917, and awarded the D.S.O. on June 4, 1917. Promoted to the rank of Lieut.-Colonel on December 12, 1918, he became A.D.V.S. of the 8th Corps, and was demobilised on April 8, 1919, when he resumed his practice in Dundee.

After the War, he continued to serve in the Territorial Army, being O.C. 51st Mobile Veterinary Section from April, 1919 to 1925, and then A.D.V.S. 51st (Highland) Division from 1925 to 1929. He gave 32 years' uninterrupted service to the Territorial Army and his decorations included, the Distinguished Service Order, the Territorial Decoration and five war medals. He was a member of the City of Dundee Territorial Association from 1920 until his death.

Although his main interests, apart from professional activities, were of a military nature, he took an active part in many other things and served on the council of the R.C.V.S. from 1930 to 1934. In his youth he was a boxer of considerable merit, and when a student he was middle-weight University champion. He was President of the Scottish Amateur Boxing Association 1937-1938 and Chairman of Dundee National Fitness Association 1938-1939. During World War II he was Petrol Officer for Veterinary Surgeons in the North of Scotland and Regimental Veterinary Officer N.A.R.P.A.C. for the City of Dundee and Rural areas, and in 1941 he was appointed Regional Veterinary Officer for the Farm Stock Emergency Service. In January, 1943, he was appointed Deputy Lieutenant for the County of the City of Dundee.

Andrew Spreull's 76 years were crowded with activity, he did not seek the limelight but by his works he earned and won the esteem of his professional brethren and of the community. He was a most competent veterinary surgeon and particularly so in all matters relating to the horse, and his service as a second opinion was valued highly by practitioners situated far beyond the radius of his own practice.

He was a man who could fight with great determination for a cause that was right and just in his opinion, no matter what forces were arrayed on the opposite side. He was genial and kind and he could fight determinedly without arousing anger in the opposition.

He was esteemed in his profession, he won the regard of the community, and he was honoured by his sovereign. Such men bring honour to our profession.

J. McC.

WILLIAM BROWN, M.R.C.V.S.

Editor of The Veterinary Record

WILLIAM BROWN, Editor of our contemporary journal *The Veterinary Record* passed away on the evening of January 1, 1954. He had spent a full day in his new office in Mansfield Street and was on his way home when he collapsed suddenly in Baker Street and died before reaching hospital. From time to time during recent years the state of his health had been the cause of concern to his friends but recently the noticeable improvement in his general appearance had raised their hopes that a recovery had occurred. The news of his sudden seizure and death therefore came as a profound shock to all who knew him and especially to his colleagues at the British Veterinary Association headquarters with whom he had spent the day and who had seen him so recently in apparently good health.

WILLIAM BROWN

He was born on February 2, 1891, and he was the younger son of William Brown, J.P., M.R.C.V.S., who practised at Wivelescombe in Somerset. He grew up in that country practice, he accompanied his father on his rounds and quite naturally he was attracted to the idea of a Veterinary career and following in the steps of his father. He told me that this ambition lost much of its attraction for his father would put him up on horses which he was asked to examine and quite often these animals would be young, wild and fractious. He had many spills. One of these was a rather severe one and it damped his youthful enthusiasm for a Veterinary Surgeon's life.

His family had been members of the Quaker fraternity for several generations and so he was educated at Sidcot School, Winscombe, which was conducted under the auspices of the Society of Friends. This was during the years 1901-1908. Whilst at this school he became interested in journalism and decided to make that profession his career. He attended a school of journalism at Taunton, and subsequently joined the staff of a provincial paper. Launched successfully in this profession he married in 1914, his bride being Dorothy Rolfe. We do not know what turned his attention to Veterinary Science again but in 1918 he entered the Royal Veterinary College as a student. Whilst he was a student the N.V.M.A. was re-constituted so that it could become a more powerful and influencial body. The existing veterinary societies joined the new organisation with the status of divisions of the parent body, and *The Veterinary Record,* a weekly periodical founded by William Hunting in 1888 and owned by Messrs. Brown of Fulham Road, the printers and publishers, was acquired so that it could serve as the official organ of the new body.

The purchase of *The Veterinary Record* was a stroke of genius on the part of our leaders at that time for there was a great apathy abroad and it is doubtful if the new association would have survived for long and gained many members if it had not been that the payment of a membership subscription entitled them to a free copy of the weekly periodical.

The purchase of *The Veterinary Record* was an act of great courage and faith. The transaction could not be measured in terms of finance although indeed this aspect was not entirely free from great anxiety. Those who conducted the negotiations were endowed also with a supreme confidence that their action was right and their vision of the future would meet with the approval of their fellows. The finances of the association were strained to the utmost, the *'Record'* had to go to press each week and the association could not afford the services of a salaried editorial staff. The editorial duties were undertaken by volunteers within the profession in the first instance by J. B. Buxton and then by the late J. T. Edwards. Edwards was then on the staff of the R.V.C. and he worked at night in the small laboratory behind the Central Lecture Theatre, and the labour was so onerous that often he had to run to Euston station to catch the last train to Birmingham so that the MSS. could be in the hands of the printers the next morning in order to keep faith with the readers on the appointed day of issue. Now by a great stroke of good fortune Wm. Brown was a student at the College at that time. It came to Edwards' notice that Brown was a qualified journalist

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and he asked for his help. Brown responded willingly and so his long association with *The Veterinary Record* began. This association continued whilst he was a student and a glance at the "Records" of those days will give good evidence of the successful efforts of Edwards and his amanuensis. When Edwards went to India in 1921 Brown continued to help assisting G. H. Livesey who filled the office of secretary of the N.V.M.A. in a voluntary and unpaid capacity.

When Brown qualified in 1923 the association was well founded although its membership list was still low. He was appointed to the post which he held under various designations until his death and also he became assistant secretary. The whole-time staff at the HQ. then consisted of Mr. Knight (secretary) and Wm. Brown. The work in the office grew in volume as the Association gradually expanded and increased in influence and membership and it was only by the loyal team work of these two men that the business of the Association and of the *'Record'* was accomplished. Brown had to search far and wide for material for the journal. He attended meetings of Veterinary Societies in many parts of the country and recorded their proceedings. He was a member of the Central Society and recorded the proceedings for 25 years.

Brown and Knight worked at first in very cramped premises in Buckingham Palace Road, then in more commodious rooms in Grays Inn Square and later in Verulam Buildings, Grays Inn.

The work grew in volume and importance. The membership of the association and its influence increased in like manner, financial conditions improved and they were able to concentrate on their specific duties and employ assistance. They witnessed the transfer to the house in Gordon Square in 1937 and finally in December, 1953 to the present superb premises in Mansfield Street.

In the march to Mansfield Street and to the position and prestige which is enjoyed by the B.V.A. to-day, we must never forget the part played by Wm. Brown. For thirty years or more he was in the background playing a vital part with characteristic modesty. Much depended upon him and he gave his heart and soul willingly and cheerfully to the task. In the dark years of war amidst all the terrors of the "blitz" he held the fort in London and the *'Record'* never failed to go to press. The strain must have been very great and although it did not register much on his cheerful exterior the nervous tension to which he was subjected could not be swept so lightly away.

In reviewing Brown's life and work it is right that this abbreviated account of the translation from the small laboratory at the R.V.C. and Buckingham Palace Road to Mansfield Street should be told and also of the great work that he and his colleague Mr. Knight have accomplished for the association and the *'Record.'* Their loyalty, diligence, competence and energy, has been a major factor in the rise and progress of the Association. As the Association grew in strength and influence and the financial affairs were organised and securely founded by the late Alfred West it became possible for Wm. Brown and Mr. Knight to concentrate all their efforts on their specific duties and employ assistants.

The business of the '*Record*' was controlled by a committee called the Editorial Committee. Brown was the executive officer and he was designated Editorial representative. For many years the committee met every Monday afternoon and the Editorial representative would place before them the material in hand and they would discuss the format for future issues and make decisions on the advisability of "Editorials" and the theme thereof. Even such matters as a paragraph for "Notes and News" and certainly every letter for the correspondence section had to be submitted for their approval. Also as the '*Record*' was the official organ of the Association material which in any way concerned "policy" had to be submitted to the Officers and may be to the council of the association. This system has continued up to the present day although the meetings of the responsible committee are not so frequent. Of late years the meetings have been held at monthly intervals and in 1945 Brown was recognised by resolution in council as Editor. In the same year the N.V.M.A. thanked him for his 25 years of loyal service and marked the occasion by presenting to him a token of their esteem.

Hemmed in by committee control, a committee whose members were subject to change, debarred of the right to act on his own initiative except in the most trivial of matters, his job was never an easy one, and most men would have broken under the strain. Fortunately for the Association and the '*Record*' he was not intimidated easily and his outlook on life and his calm equitable temperament enabled him to carry on and work for his beloved '*Record*.' He saw the periodical go through the hazards of a re-birth, he saw great changes in its character and format, he lived to witness its universal recognition as a scientific journal of merit.

I was priviledged to know Wm. Brown and call him friend for thirty years. He was about 5 ft. 10 in. and spare in frame yet his muscles were firm and he walked with an erect and vigorous air. His complexion belied his liking for the open air and for many years he did not wear a hat. His head was covered by a well groomed mass of hair which, as it turned to grey, gave him a distinguished appearance. His voice rang kind, his speech was precise and tinged with the Somerset tongue. He was most meticulous in his work and seemed to do everything at the right time and place and his office had a tidy and well ordered appearance which one does not always associate with an Editor's Sanctum. He kept very regular hours and one could have set a watch by his coming and going. Knowing this one could always contact him with great certainty on the telephone and on the many occasions on which I visited his office I always found him at work editing, reading proofs, or making up the format for the next issue.

He could speak with both tongue and pen but the restrictions of his office were such that we of the Veterinary Profession never heard or read his words when in full flow. There are many who regret this and consider that he had the ability to have wrought much good to the profession

He had a happy home life and his principal hobbies were gardening, music, cricket, swimming and rowing. In August last he achieved a life-long desire, a

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house by the sea. It was at Saltdean on the South Coast. In the ordinary course of events he was due to retire in a few years and no doubt he was looking forward to many happy hours in his garden by the sea.

Wm. Brown was a kind and gentle man whose life and actions were conducted according to the precepts of the Christian faith as observed by the Society of Friends. He was never heard to speak ill of anyone and he earned the respect of all who came in contact with him.

His passing is a great loss to the B.V.A. and to the profession. We mourn a loyal servant and friend who in a quite unostentatious way did much to advance the science and art of Veterinary Medicine.

The funeral service was conducted at Golders Green Crematorium on Thursday, January 7 and was attended by Veterinary Surgeons representing all branches of the profession.

We hope that his widow and son and other relatives may gain comfort in their grief from the knowledge that by his works Wm. Brown had won the respect and love of his professional brethren and an honoured place in Veterinary history.

J. McC.

NEWS

THE Queen has sent a donation to the Animal Health Trust.

The Trust, founded in 1942, is the only voluntary organisation exclusively concerned with research into animal ill-health which costs this country £80 million a year. It has four research stations, respectively for dogs, horses, poultry and farm livestock and in addition, it gives scholarships and fellowships for higher veterinary education.

The following gentlemen have recently accepted invitations to join the Council of the Animal Health Trust: His Grace the Duke of Devonshire, M.C.; D.V.S.M., Director of the Ministry of Agriculture's Veterinary Laboratory at Weybridge; Mr. Thomas Peacock, C.B.E., J.P., Chairman of the Milk The Rt. Hon. the Earl Peel; Dr. A. W. Stableforth, D.Sc., M.R.C.V.S., Marketing Board; Sir William Cooper.

NOTICE

WE have been asked by Messrs. A. J. White Ltd., to draw the attention of our readers to the new reduced prices of "Nefco" now in operation: 3½ oz. carton, 2s. 9d. each; 14 oz. carton, 9s. 6d. each; 5 lb. drum, 43s. each; 28 lb. drum, 222s. each. "Nefco" is not subject to purchase tax.

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THE BRITISH VETERINARY JOURNAL, with which is incorporated THE VETERINARY JOURNAL, is published monthly, and copy for advertisements should be in the hands of the advertisement manager not later than the 20th of the preceding month, if proof is required. Tel.: Temple Bar 3386.

Letters for the Journal, literary contributions, reports, notices, books for review, exchanges, new instruments or materials, and all matter for publication (except advertisements) should be addressed to the Editor.

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